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SAMS Acceleration Measurements on Mir From January to May 1997 (NASA Increment 4)

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National Aeronautics and
Space Administration

Lewis Research Center

October 1998

Available from

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(NASA Increment 4)**

September 10, 1998

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Abstract

During NASA Increment 4 (January to May 1997), about 5 gigabytes of acceleration data were collected by the Space Acceleration Measurement System (SAMS) onboard the Russian Space Station, Mir. The data were recorded on 28 optical disks which were returned to Earth on STS-84. During this increment, SAMS data were collected in the Priroda module to support the Mir Structural Dynamics Experiment (MiSDE), the Binary Colloidal Alloy Tests (BCAT), Angular Liquid Bridge (ALB), Candle Flames in Microgravity (CFM), Diffusion Controlled Apparatus Module (DCAM), Enhanced Dynamic Load Sensors (EDLS), Forced Flow Flame Spreading Test (FFFT), Liquid Metal Diffusion (LMD), Protein Crystal Growth in Dewar (PCG/Dewar), Queen's University Experiments in Liquid Diffusion (QUELD), and Technical Evaluation of MIM (TEM). This report points out some of the salient features of the microgravity environment to which these experiments were exposed. Also documented are mission events of interest such as the docked phase of STS-84 operations, a Progress engine burn, Soyuz vehicle docking and undocking, and Progress vehicle docking. This report presents an overview of the SAMS acceleration measurements recorded by 10 Hz and 100 Hz sensor heads. The analyses included herein complement those presented in previous summary reports prepared by the Principal Investigator Microgravity Services (PIMS) group.

Acronyms and Abbreviations

ALB	Angular Liquid Bridge
BKV-3	Vozdukh dehumidifier (Russian acronym)
BTS	Biotechnology System
CFM	Candle Flames in Microgravity
DCAM	Diffusion Controlled Apparatus Module
DMT	Decreed Moscow Time (year day/hour:minute:second)
f_c	cutoff frequency (Hertz)
ftp	file transfer protocol
g	acceleration level referenced to g_0
g_0	acceleration due to Earth's gravity (9.81 m/s ²)
Hz	Hertz
LeRC	Lewis Research Center
LMD	Liquid Metal Diffusion
μg	microgravity (1/1,000,000 of g_0)
MGBX	Microgravity Glovebox
MIM	Microgravity Isolation Mount
MiPS	Mir Payload Support
MiSDE	Mir Structural Dynamics Experiment
MOST	Mir Operations Support Team
MRD	Microgravity Research Division
PIMS	Principal Investigators Microgravity Services
POSA	Payload Operations Support Area
PSD	power spectral density
QUELD	Queen's University Experiments in Liquid Diffusion
RCS	Reaction Control System
RMS	root-mean-square
SAMS	Space Acceleration Measurement System
STS	Space Transportation System
TEM	Technical Evaluation of MIM
TSH	triaxial sensor head
URL	Uniform Resource Locator
WWW	World Wide Web
X_h, Y_h, Z_h	X-, Y-, Z-Axis for unspecified SAMS sensor head
$X_{h,A}, Y_{h,A}, Z_{h,A}$	X-, Y-, Z-Axis for SAMS TSH A
$X_{h,B}, Y_{h,B}, Z_{h,B}$	X-, Y-, Z-Axis for SAMS TSH B
X_B, Y_B, Z_B	X-, Y-, Z-Axis coordinate system for Mir Base Block

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Acknowledgments

The author would like to acknowledge a number of people who contributed time and effort to provide information which was used in this report. I would like to acknowledge the SAMS group (NASA LeRC) for providing the hardware, and for processing the data from the optical disks to engineering units. John Linenger performed an exceptional job of operating the SAMS unit, as well as keeping a logbook of some significant acceleration events which occurred during his stay on Mir. The NASA JSC POSA group's daily summaries proved to be an invaluable tool for the analysis of this data. Ken Hrovat and Milton Moskowitz were invaluable again in developing the data plots for this report. Tim Reckart was very important in pulling the report together. Gene Liberman was invaluable for his Russian-to-English skills (both verbal and written). I would like to thank Julio Acevedo (NASA LeRC, SAMS-Mir Project Manager) for his continued efforts to keep SAMS recording on Mir, and for insuring that PIMS had access to the Russian experts.

1. Introduction

The NASA Microgravity Research Division (MRD) sponsors microgravity science experiments on several carriers, which include the Shuttle Orbiter and the Mir Space Station. The MRD sponsors the Space Acceleration Measurement System (SAMS) at the NASA Lewis Research Center (LeRC) to support microgravity experiments with acceleration measurements. The LeRC Principal Investigator Microgravity Services (PIMS) project supplies principal investigators of microgravity science experiments and other experiment personnel with data to support the evaluation of the effects of microgravity on their experiments. PIMS also provides information about on-orbit events such as equipment operation, reaction control system (RCS) jet firings, crew exercise periods, etc. to assist in the scheduling of microgravity science experiment operations.

In 1994, a SAMS unit [1] was installed on the Mir Space Station to support U.S. and Russian microgravity experiments by measuring the microgravity environment during experiment operations. Previous reports [2-7] have summarized and evaluated the SAMS data acquired during the period from September 1994 to January 1997.

During NASA Increment 4 (January to May 1997), the SAMS unit supported experiments conducted in the Priroda module, including the Diffusion Controlled Apparatus Module (DCAM) experiments, Angular Liquid Bridge (ALB) experiment, experiments conducted in the Microgravity Isolation Mount (MIM) such as the Technical Evaluation of MIM (TEM), the Liquid Metal Diffusion (LMD) experiment, and the Queen's University Experiments in Liquid Diffusion (QUELD), and experiments conducted in the Microgravity Glovebox (MGBX) including the Forced Flow Flame Spreading Test (FFFT), and the Candle Flames in Microgravity (CFM) experiments.

Data was recorded to support and characterize a number of events, such a firing of the Progress vehicle's engine to reboost Mir and docking operations of Soyuz, Progress, and Orbiter vehicles. The data also provided insight into the accelerations resulting from two different attitudes of Mir.

This report provides an overview of the SAMS data recorded during the NASA Increment 4 over the period from January to May 1997.

Appendix A describes the procedures that users should follow to access SAMS data over the internet via anonymous file transfer protocol (ftp). Appendices B and C contain spectrograms of the data from the two SAMS sensor heads. The data plots in appendices B and C are viewable from the attached CD-ROM. Appendix D contains a user comment sheet, which users are encouraged to complete and return to the authors.

This entire report is also viewable from the attached CD-ROM and available on the World Wide Web (WWW) in the portable document format (PDF). Adobe Acrobat Reader version 2.1 or higher will be necessary to open and/or print these files.

2. Data Acquisition and Processing

As noted in previous reports [2-7], the SAMS unit on Mir is connected to two triaxial sensor heads (TSHs). TSH A has a cutoff frequency of 100 Hz and a sampling rate of 500 samples per second. TSH B has a cutoff frequency of 10 Hz and a sampling rate of 50 samples per second. During NASA Increment 4, the SAMS unit was turned on periodically to record microgravity accelerations in support of the various experiments and other significant events. SAMS data coverage for this time period is shown in Figure 1.

Twenty-eight optical data disks were returned to Earth on STS-84, marking the completion of NASA Increment 4 in May 1997. These data were processed by the SAMS project at LeRC and placed on a NASA LeRC file server (beech.lerc.nasa.gov) to make them available to users. Appendix A of this report provides instructions for accessing these data files.

3. Mir Space Station

3.1 Mir Configuration

The Mir has been in orbit since February 1986, and, in the years since, modules have been added until the Mir reached its present configuration of six modules. The Mir currently consists of the Base Block, the Kvant, Kvant-2, Kristall, Spektr (currently depressurized and uninhabitable), and Priroda modules. It measures more than 32 meters in length with the docked Progress-M and the Soyuz-TM spacecraft and is about 27 meters in width across the modules. Figure 2 shows the normal daily activities on the Mir. Figure 3 shows a typical configuration of the Mir Space Station with a docked NASA Orbiter during the time covered by this report.

3.2 Mir Coordinate Systems

The Mir Space Station's basic coordinate system is that of the Base Block module coordinate system that is shown in Figure 4. Each of the modules of the Mir station has its own coordinate system, which is based upon its orientation with respect to the Mir base block module. The determination of the coordinate system is made by a simple procedure. If you "stand" in any module, such that your feet are on the floor, and you are facing towards the transitional node of the Base Block module, then the coordinate system of that module is defined by the right hand rule, such that the direction you are facing is $+X_{\text{module}}$, the direction from your feet to your head is $+Y_{\text{module}}$, and the direction from your left to right is $+Z_{\text{module}}$. Figure 4 shows a graphical representation of these coordinate systems for the nominal Mir configuration (consistent with that shown in Figure 3). Table 1 is a tabular representation of Figure 4.

3.3 Mir Attitudes

The orientation attitudes of the Mir space station during the period from January to May 1997 are not known at this time. There are references in the Mir Operations Support Team (MOST) notes [8] which indicate that on 13 February 1997 the Mir was in an Earth-oriented attitude and on 23 February 1997 was in a solar inertial attitude. The resultant measured acceleration levels are discussed in section 8.5.

4. SAMS Triaxial Sensor Head Orientations and Locations

Table 2 shows the TSH orientations and locations for the time period of NASA Increment 4.

5. Facilities Supported

Additional information on these facilities may be obtained from [9].

5.1 Microgravity Glovebox (MGBX)

The glovebox facility is used to conduct experiments associated with combustion experiments and hazardous operations which need to be isolated from the Mir living environment.

5.2 Microgravity Isolation Mount (MIM)

The MIM is used to isolate some experiments from the vibrations and accelerations of the Mir space station.

6. Experiments Supported

Additional information on these experiments may be obtained from [9].

6.1 Angular Liquid Bridge (ALB)

This experiment examined how microgravity affects a fundamental fluid physics model of a fluid equilibrium interface. This was conducted with the ALB apparatus in the MGBX facility.

6.2 Candle Flames in Microgravity (CFM)

Scientists studied combustion and flame diffusion in microgravity independent of buoyancy-induced flow. This was conducted with the CFM apparatus in the MGBX facility.

6.3 Diffusion Controlled Apparatus Module (DCAM)

Scientists grew protein crystals in space and evaluated the dialysis and liquid/liquid diffusion methods of crystal growth.

6.4 Enhanced Dynamic Load Sensors (EDLS)

Investigators measured the crew-induced disturbances with the goal of quantifying the possible effects these disturbances may have on the spacecraft and vibration-sensitive experiments [10].

6.5 Forced Flow Flame Spreading Test (FFFT)

Scientists studied the effects of microgravity on the spread and growth of a flame using air flow acting on the flame. This experiment was conducted with the FFFT apparatus in the MGBX facility.

6.6 Liquid Metal Diffusion (LMD)

Scientists attempted to prevent any void/bubble formation in liquid metal diffusion samples in microgravity. This experiment was conducted with the LMD apparatus in the MIM facility.

6.7 Mir Structural Dynamics Experiment (MiSDE)

Investigators used this experiment to obtain structural dynamic response data on the Mir vehicle and the Mir/Shuttle vehicles in a mated configuration during normal operational events such as docking, Shuttle and Mir thruster jet firings, crew exercise, and other crew activities.

6.8 Protein Crystal Growth in Dewar (PCG/Dewar)

Investigators studied protein crystal growth in microgravity and evaluated flash-frozen and liquid/liquid diffusion methods.

6.9 Queen's University Experiments in Liquid Diffusion (QUELD)

This experiment collected data on diffusion coefficients in the melt of metal alloy systems devoid of gravitational effects. This experiment was conducted with the QUELD apparatus in the MIM facility.

6.10 Technical Evaluation of MIM (TEM)

Scientists evaluated the proper functioning of MIM in terms of its ability to isolate fluid physics experiments from accelerations and vibrations.

7. Data Analysis Techniques

SAMS data are generally presented and plotted in one of several forms for evaluation: acceleration versus time, interval average acceleration versus time, power spectral density (PSD) versus frequency, and spectrogram (PSD versus frequency versus time). The form used depends on what aspect of the data is of interest. These techniques are described in detail in [11].

Acceleration versus time plots are used to display the acceleration levels recorded by the SAMS sensor head. These data could then be used by experiment personnel to correlate experiment results with the measured microgravity environment. This form of data display gives the most time-accurate representation of the microgravity environment.

A plot of the interval average acceleration in units of acceleration versus time gives an indication of net accelerations which last for a number of seconds equal to or greater than the interval parameter. Shorter duration, high amplitude accelerations can also be detected with this type of plot. However, the exact timing and magnitude of specific acceleration events cannot be extracted. A plot of the interval root-mean-square acceleration in units of acceleration versus time gives an indication of the time-averaged power in the signal due to oscillatory acceleration sources.

Power spectral density (PSD) calculations and plots are used to examine and display the frequency content of SAMS data during relatively short periods of time (on the order of seconds to minutes). Analysis times may be chosen based upon some specific event or experiment operation. For SAMS data, the PSD units are g^2/Hz .

Spectrograms are 3-dimensional plots, but, as presented here, the third dimension is color, so all the data can be presented on a 2-dimensional plot. Spectrograms can be used to evaluate how the microgravity environment varies in intensity with respect to both the time and frequency domains.

8. Microgravity Environment

Many features of the Mir microgravity environment have been described in previous reports [2-7] and will not be described again here. These features are attitude control thrusters, crew exercise, and life support system fans. Disturbances unique to this time period are described here.

8.1 Shuttle/Mir Docking

SAMS data was acquired during the STS-84 docking to Mir at DMT: 1997/137/06:33.

8.2 Mir Reboost by Progress Vehicle Engine

Figure 5 shows an acceleration versus time plot for the time which included the firing of the Progress vehicle's engine to reboost the altitude of Mir on 15 April 1997 [8]. The resultant altitude boost is seen in Figure 6 [12]. Notice that the $Z_{h,B}$ sensor head axis shows an offset of 2,200 μg for a duration of 138 seconds. This offset indicates the time, intensity, and duration of the Progress vehicle's engine firing. Applying the appropriate coordinate transformations, this disturbance is consistent with the thrust direction when the Progress vehicle is docked at the Kvant 1 module. Vibrations of the Mir structure resulting from the impulsive action of the thruster turning on and off may be seen in all axes whereas the main thrust action was primarily in the $-X_B$ direction. The magnitude of this acceleration is similar to that reported earlier [7], but is opposite in direction due to the difference in the Progress' location.

8.3 Soyuz Vehicle Docking and Undocking to Mir

Figure 7 shows a color spectrogram of SAMS data recorded during the docking of Soyuz TM-25 to Mir at DMT 1997 043/20:13 (12 February) which brought crew members Vasili Tsibliyev and Alexander Lazutkin to Mir. The docking occurred just before hour 3 in this plot and is apparent by the change to the structural mode frequency trace at about 1.8 Hz at that time.

Figure 8 shows a color spectrogram of SAMS data recorded during the undocking of Soyuz TM-24 from Mir at DMT 1997 061/06:25 (2 March) which brought crew members Valery Korzun and Alexander Kaleri to Earth. The undocking occurred shortly before hour 4.5 in this plot and is apparent by the disappearance of the frequency trace around 7.5 Hz, the appearance of the frequency trace at 2.6 Hz, and the frequency shift in the structural mode frequency trace at about 1.9 Hz at that time.

8.4 Progress Vehicle Docking to Mir

Figure 9 shows a color spectrogram of SAMS data recorded during the docking of Progress to Mir at DMT 1997 098/20:30 on (8 April). The docking occurred at about hour 8.5 in this plot and is apparent by the disappearance of the frequency trace around 2.4 Hz, the appearance of the frequency trace at 2.6 Hz, and the frequency shift in the structural mode frequency trace at about 1.8 Hz at that time.

8.5 Orbital Variations in Acceleration by Attitude

As mentioned earlier, POSA notes indicate that on 13 February 1997 the Mir was in an Earth-oriented attitude and on 23 February 1997 was in a solar inertial attitude. Figure 10 shows an interval average acceleration versus time plot (interval=30 seconds) of SAMS data recorded on 13 February 1997. The Earth-oriented attitude presents a nearly constant frontal area (except for solar-oriented photovoltaic arrays) to the atmosphere. This results in a relatively constant drag acceleration component in the direction of flight. The atmospheric density changes and changes in the photovoltaic arrays during one orbit produce the variable acceleration levels seen in Figure 10.

Figure 11 shows an acceleration versus time plot of SAMS data recorded on 23 February 1997. This solar inertial attitude presents a constantly changing frontal area to the atmosphere due to the fact that it "tumbles" once per orbit with respect to the Earth. This results in a constantly changing drag acceleration component in the direction of flight, which itself changes constantly during each orbit. In Figure 11 three variable axes may be seen.

9. Summary

This report presents analyses of the SAMS data recorded on the Mir Space Station from January to May 1997. During NASA Increment 4, the SAMS supported MiSDE, BCAT, ALB, CFM, DCAM, EDLS, FFT, LMD, PCG/Dewar, QUELD, and TEM.

10. References

References indicated with * may be found on the WWW from the PIMS page at URL:

<http://www.lerc.nasa.gov/WWW/MMAP/PIMS/HTMLS/reportlist.html>

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<http://www.hq.nasa.gov/osf/mir/#2line>

Table 1: Tabular representation of Mir module orientations

<i>Base</i>	<i>Kristall</i>	<i>Kvant</i>	<i>Kvant-2</i>	<i>Priroda</i>	<i>Spektr</i>
$+X_B$	$+Z_{Kristall}$	$-X_{Kvant}$	$+Y_{Kvant-2}$	$-Z_{Priroda}$	$-Y_{Spektr}$
$+Y_B$	$-Y_{Kristall}$	$+Y_{Kvant}$	$-X_{Kvant-2}$	$-Y_{Priroda}$	$+X_{Spektr}$
$+Z_B$	$+X_{Kristall}$	$-Z_{Kvant}$	$+Z_{Kvant-2}$	$-X_{Priroda}$	$+Z_{Spektr}$

Table 2: SAMS TSH Orientation

Dates	DMT 1997 Day	Location	TSH A	TSH B
1 January 1997	001	Priroda	BTS $X_{h,A} = -Y_{Priroda}$ $Y_{h,A} = +X_{Priroda}$ $Z_{h,A} = +Z_{Priroda}$	MGBX $X_{h,B} = +Y_{Priroda}$ $Y_{h,B} = -X_{Priroda}$ $Z_{h,B} = +Z_{Priroda}$
31 January 1997	031	Priroda	MIM $X_{h,A} = +Z_{Priroda}$ $Y_{h,A} = +X_{Priroda}$ $Z_{h,A} = +Y_{Priroda}$	MGBX $X_{h,B} = +Y_{Priroda}$ $Y_{h,B} = -X_{Priroda}$ $Z_{h,B} = +Z_{Priroda}$

Table 3: SAMS data recording location, times, experiments and activities

Recording Location	DMT Start (year/day)	Experiments and comments
Priroda	1997/031	MIM, SAMS TSH from BTS to MIM, SAMS calibration
Priroda	1997/034	SAMS, ALB, LMD Sample 2 on MIM. MGBX checkout
Priroda	1997/035	SAMS, ALB, LMD Sample 2 on MIM, SAMS disk change
Priroda	1997/036	SAMS, ALB, LMD Sample 2 on MIM, SAMS disk change
Priroda	1997/037	Progress undocking, SAMS, ALB, LMD Sample 2 on MIM
Priroda	1997/038	Soyuz redocking, SAMS, LMD Sample 2 on MIM, Mir deactivation
Priroda	1997/039	SAMS, LMD Sample 2 completed on MIM
Priroda	1997/043	SAMS activation, Soyuz TM-25 docking
Priroda	1997/044	SAMS deactivation, metal washer in glovebox fan
Priroda	1997/054	O2 Candle fire late in day
Priroda	1997/055	no science operations due to emergency last night
Priroda	1997/056	SAMS, LMD Sample 3 on MIM, EDLS, restricted exercise
Priroda	1997/057	SAMS, LMD Sample 3 on MIM, Jerry L. is exercising with only expanders
Priroda	1997/058	SAMS, LMD Sample 3 on MIM, EDLS passive. MiSDE
Priroda	1997/059	SAMS, LMD Sample 3 on MIM, EDLS active & passive
Priroda	1997/060	SAMS, LMD Sample 3 completion on MIM,
Priroda	1997/061	Soyuz TM-24 undocking, SAMS, LMD
Priroda	1997/063	SAMS, LMD Sample 4 on MIM, BTS, unsuccessful docking of Progress
Priroda	1997/064	BTS, SAMS, LMD Sample 4 on MIM
Priroda	1997/065	SAMS, LMD Sample 4 on MIM, EDLS active
Priroda	1997/066	SAMS, LMD Sample 4 on MIM
Priroda	1997/067	SAMS, LMD Sample 4 on MIM, EDLS
Priroda	1997/069	SAMS, EDLS active, work on Kvant 2 gyrodyne controller
Priroda	1997/070	SAMS, OFFS, work on Kvant 1 gyrodyne #2 controller
Priroda	1997/071	SAMS, OFFS, gently "pounding" on OFFS vacuum bottle
Priroda	1997/072	SAMS, EDLS passive, OFFS
Priroda	1997/073	SAMS, EDLS passive, OFFS, body mass measurement
Priroda	1997/090	SAMS, QUELD samples E9, MiSDE
Priroda	1997/091	SAMS, BTS, QUELD sample E8
Priroda	1997/098	Progress docking, SAMS, MiSDE, body mass measurements
Priroda	1997/105	Mir reboost with Progress engine, SAMS, QUELD sample E-26
Priroda	1997/106	SAMS, QUELD samples E-14 & -27, crew continues exercise 1 hour /day
Priroda	1997/137	SAMS, MiSDE, STS-84 docking
Priroda	1997/140	SAMS

SAMS ACCELERATION MEASUREMENTS ON MIR FROM JANUARY TO MAY 1997

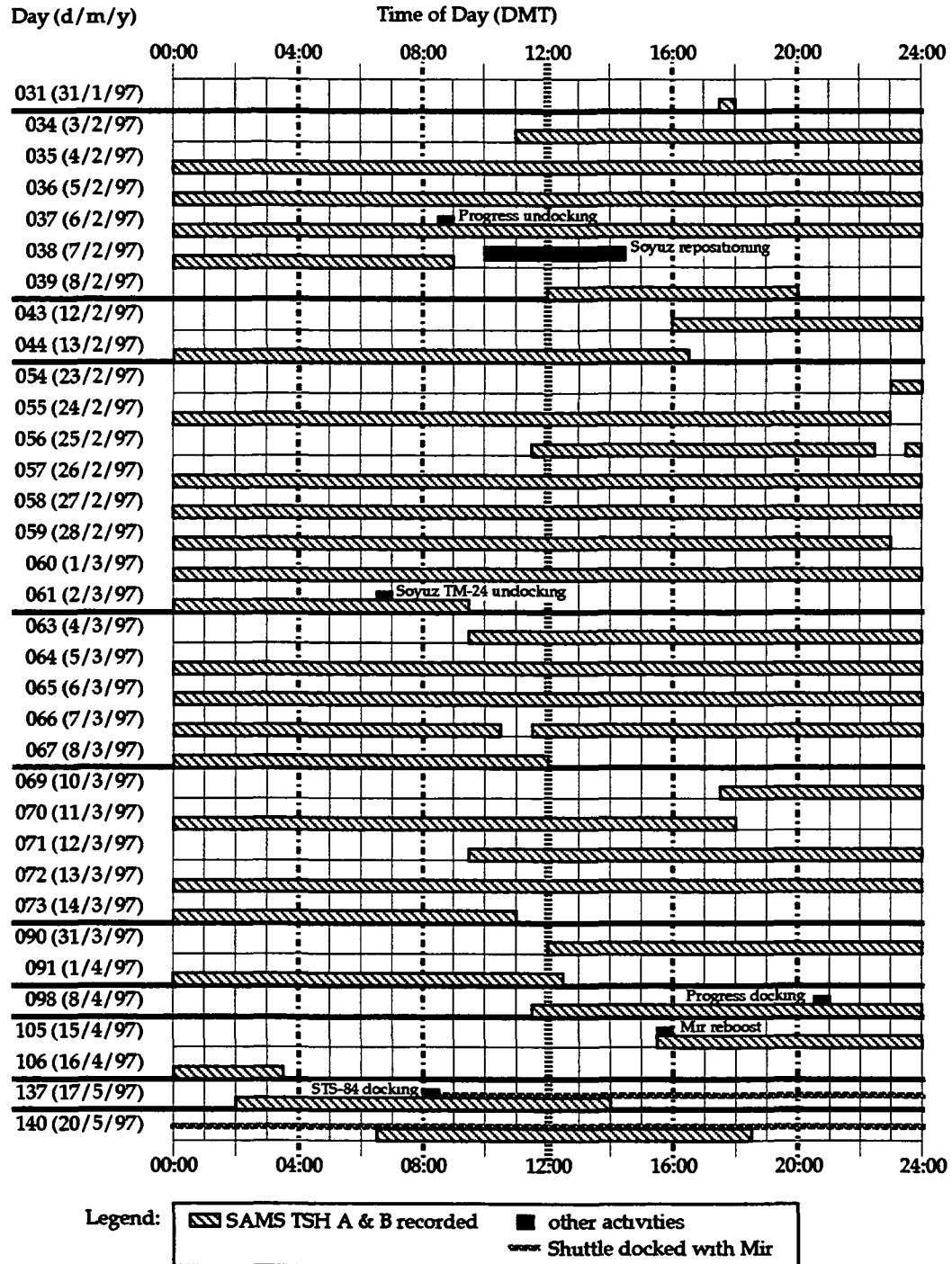


Figure 1. Mir activities and SAMS recording times during 1997

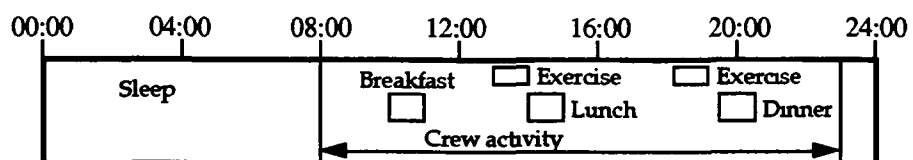


Figure 2. Typical Mir crew activities during a day in 1997

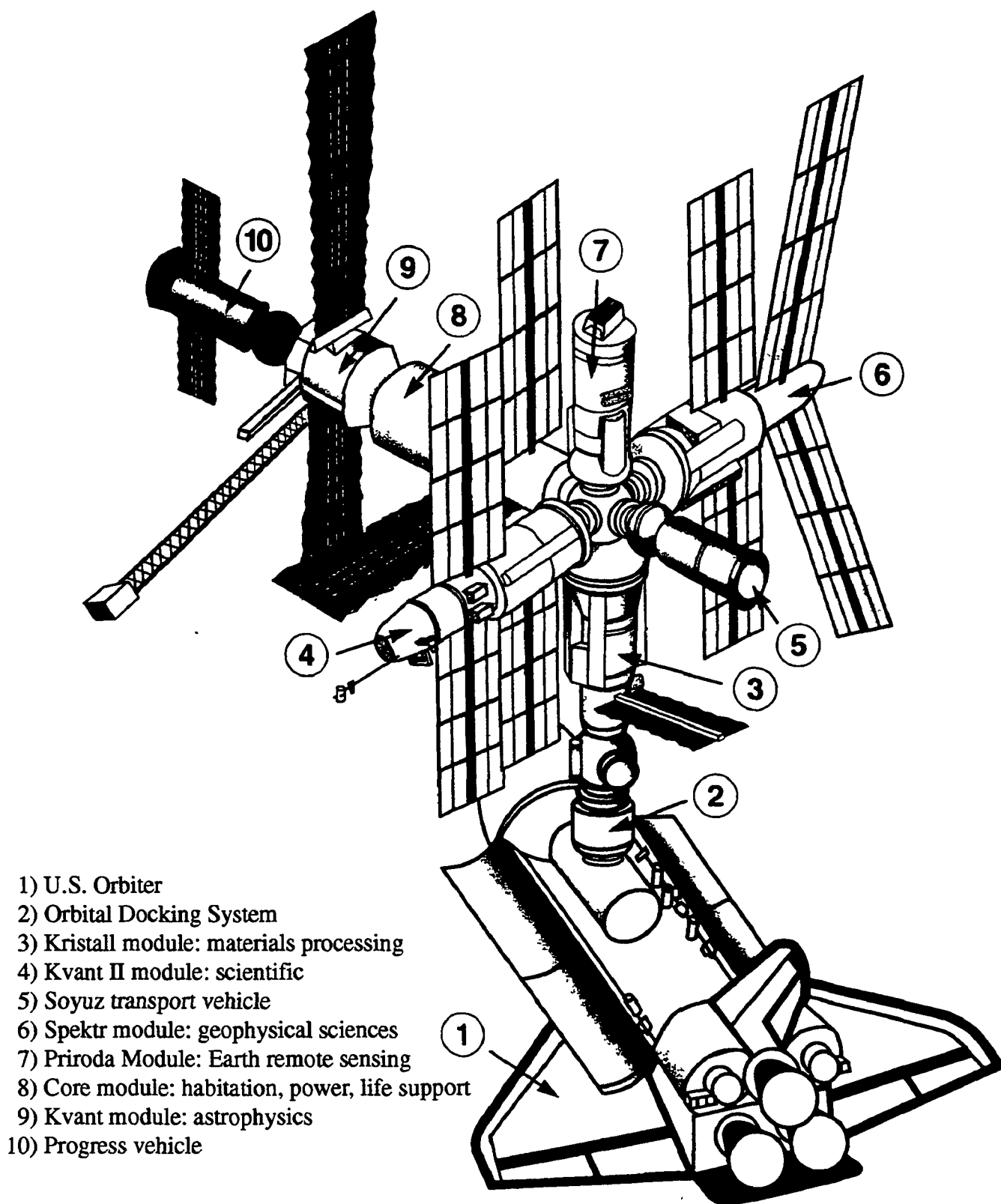


Figure 3. Mir and docked NASA Orbiter

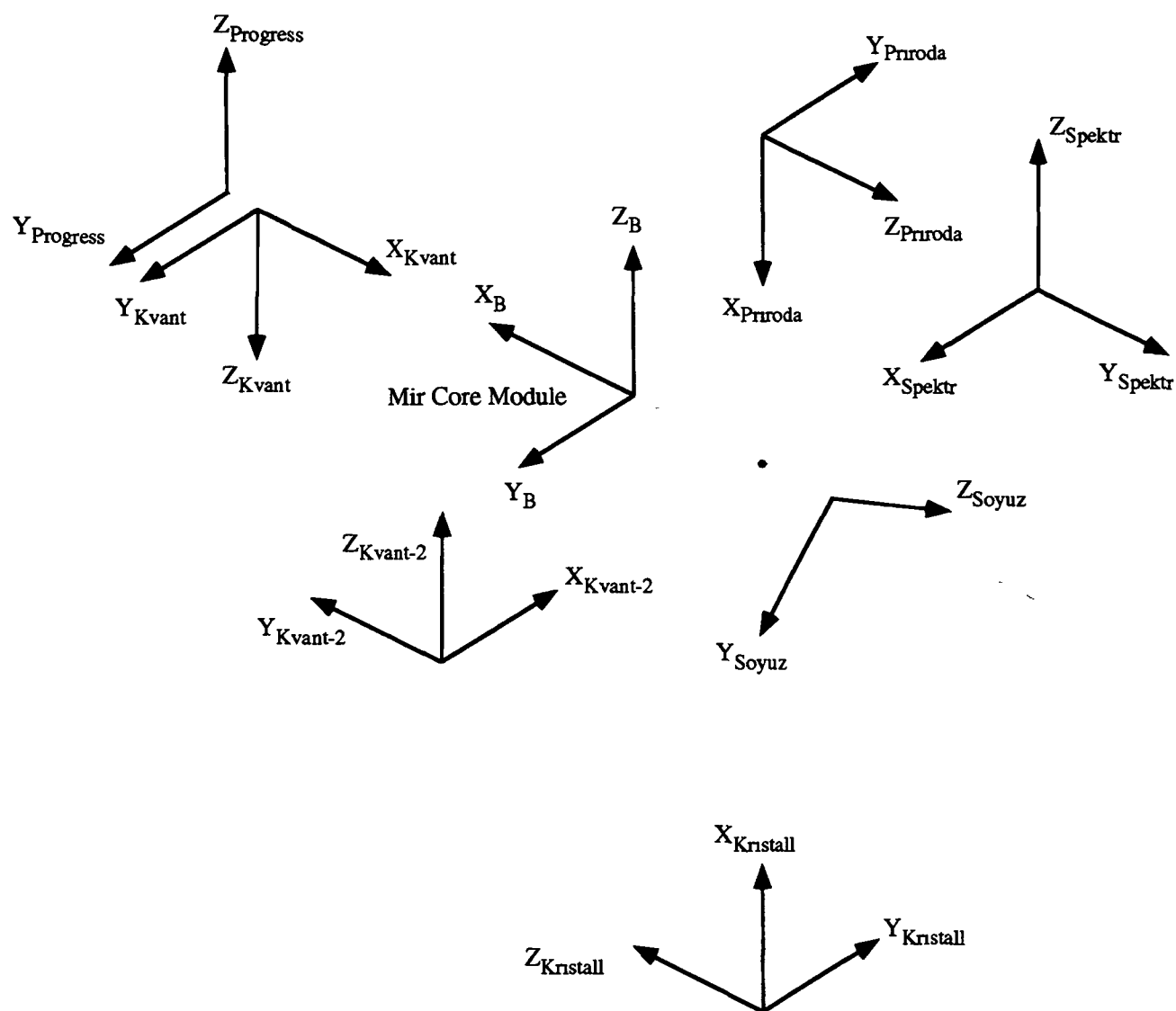


Figure 4. Mir coordinate systems by Mir and modules

SAMS ACCELERATION MEASUREMENTS ON MIR FROM JANUARY TO MAY 1997

Head B, 10.0 Hz
fs=50.0 samples per second

Mir Reboost by Progress Engine
DMT Start at 105/15:39.59.996

MIR-1997
SAMS Coordinates
T=10.0 minutes

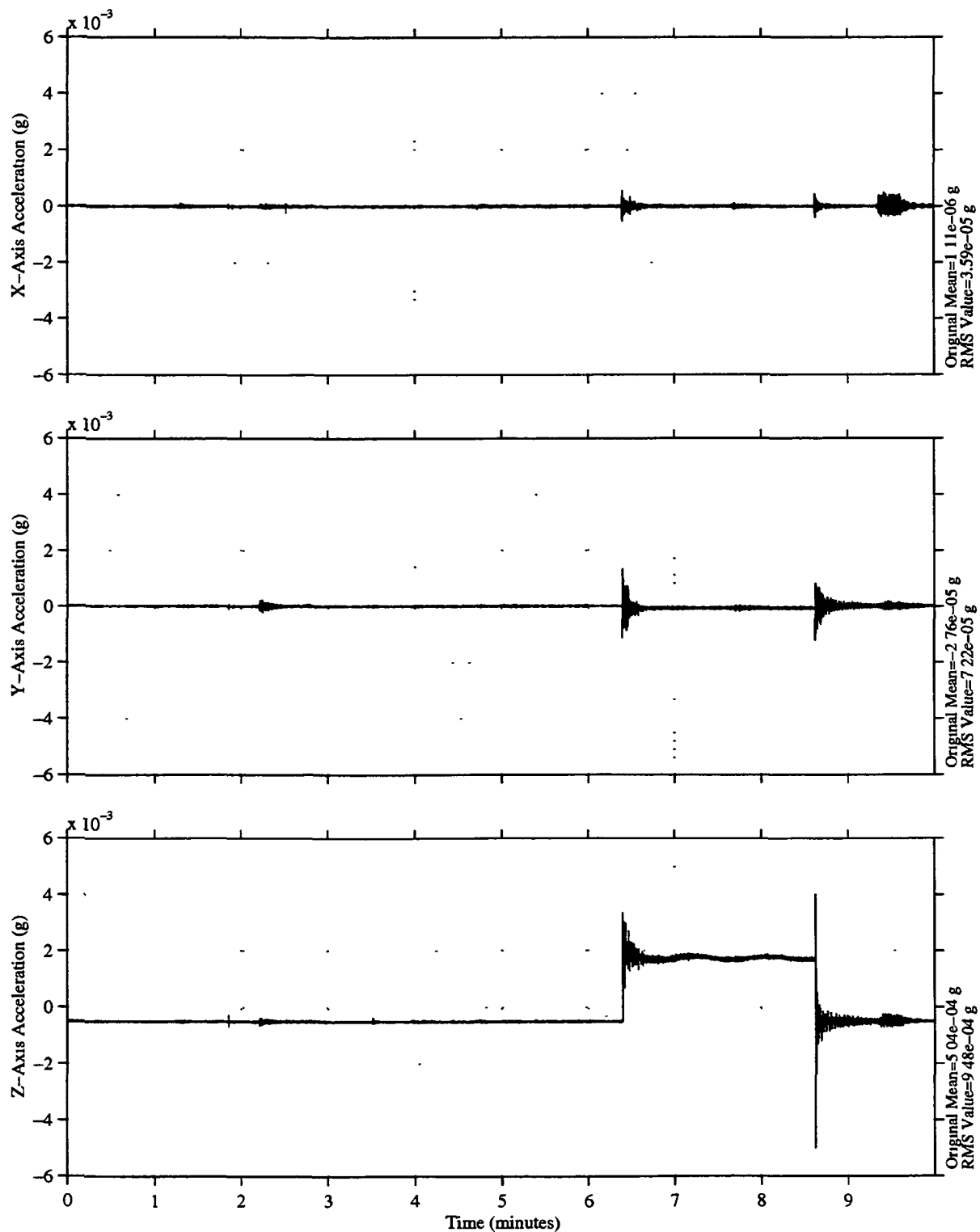


Figure 5. Reboost Operation

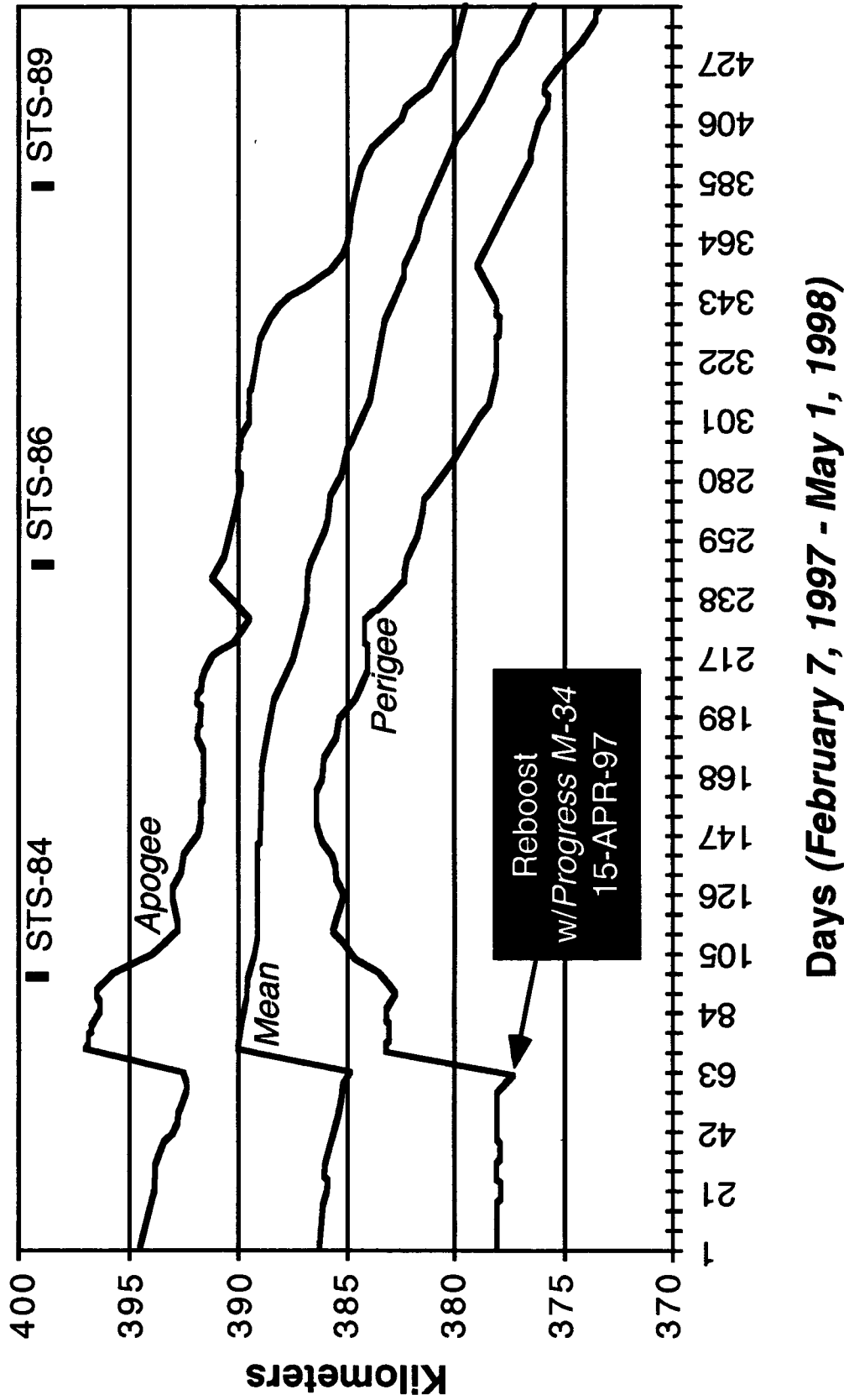


Figure 6. Attitude of Mir from February 7, 1997 to May 1, 1998. [12]

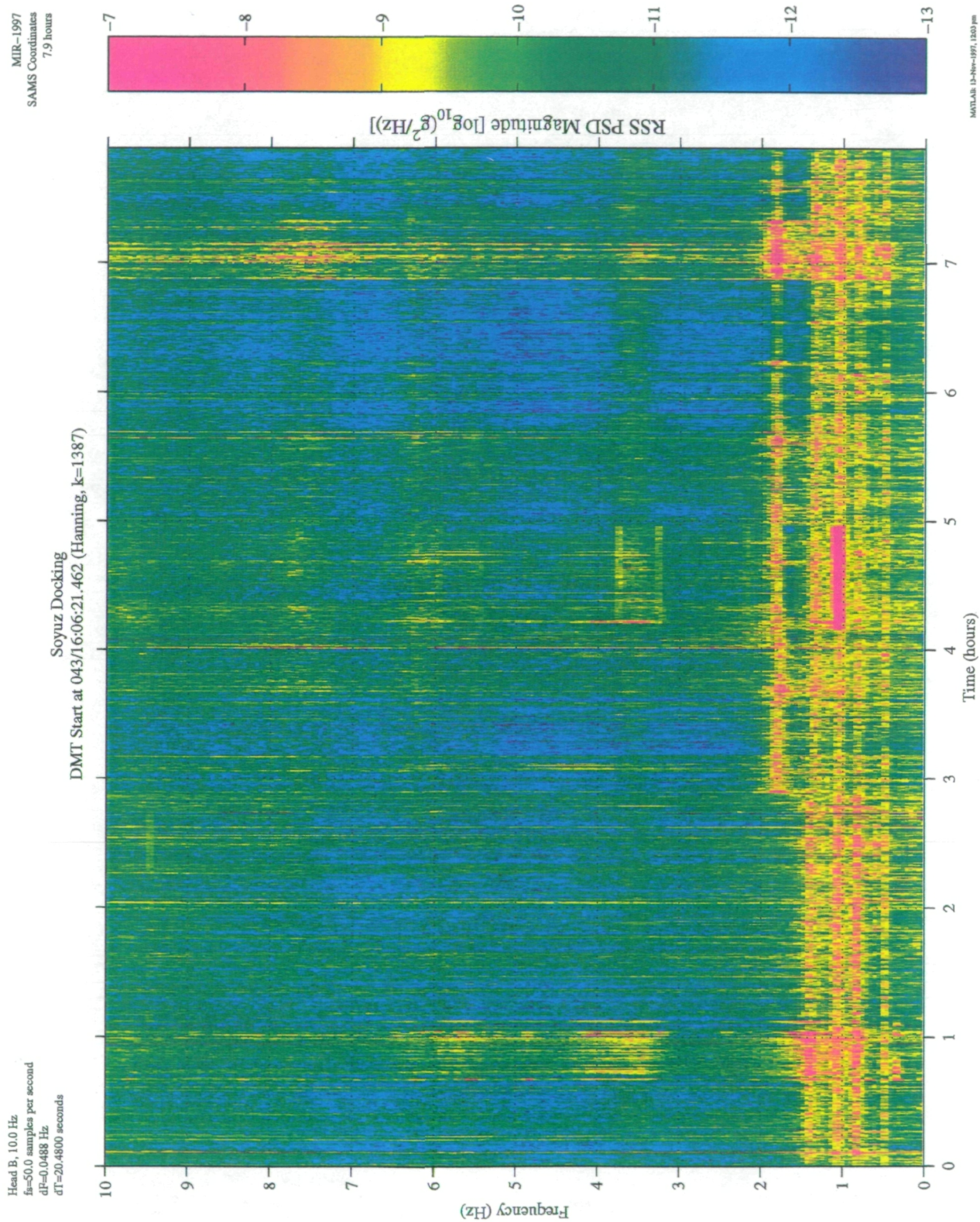


Figure 7. Soyuz docking

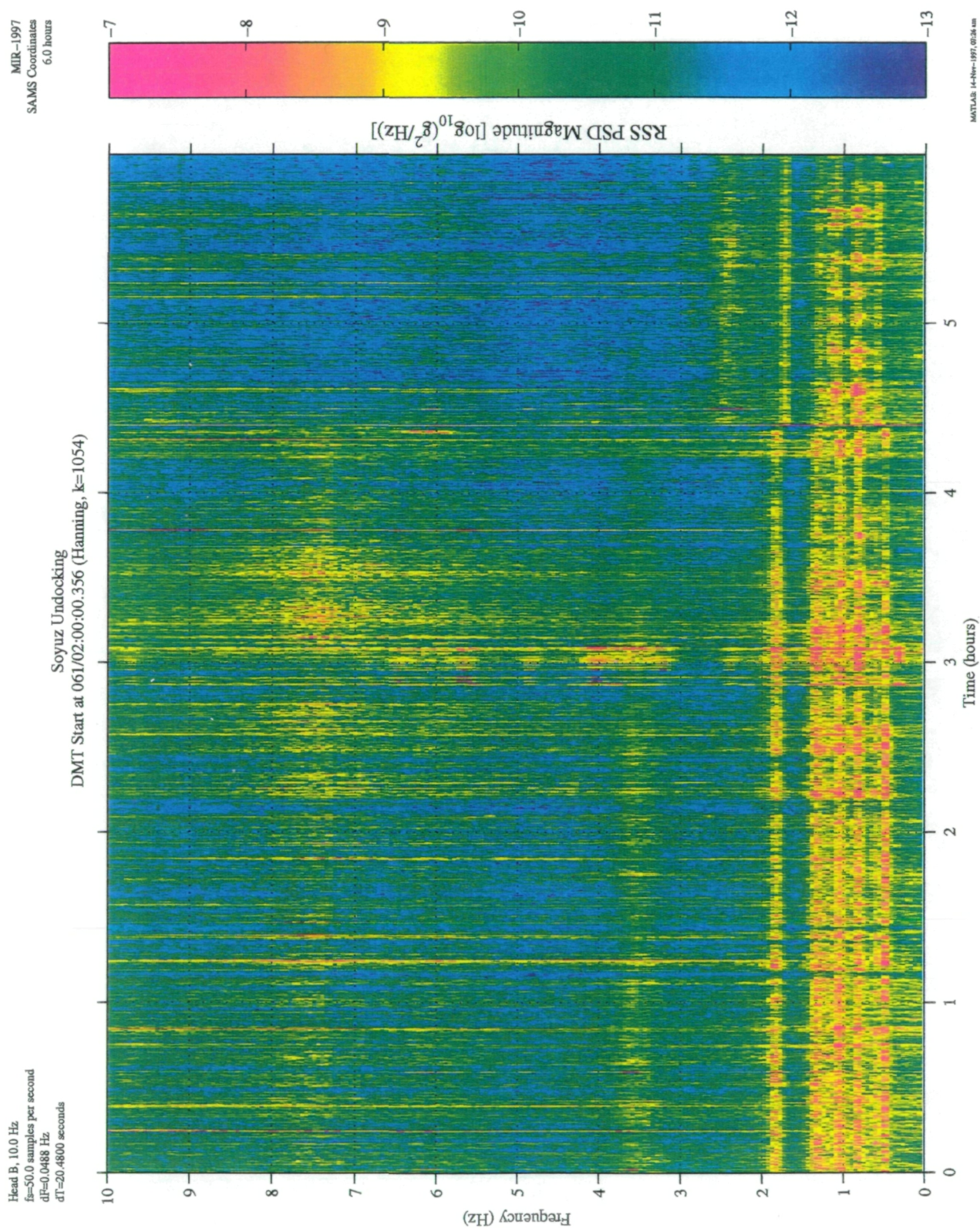


Figure 8. Soyuz undocking

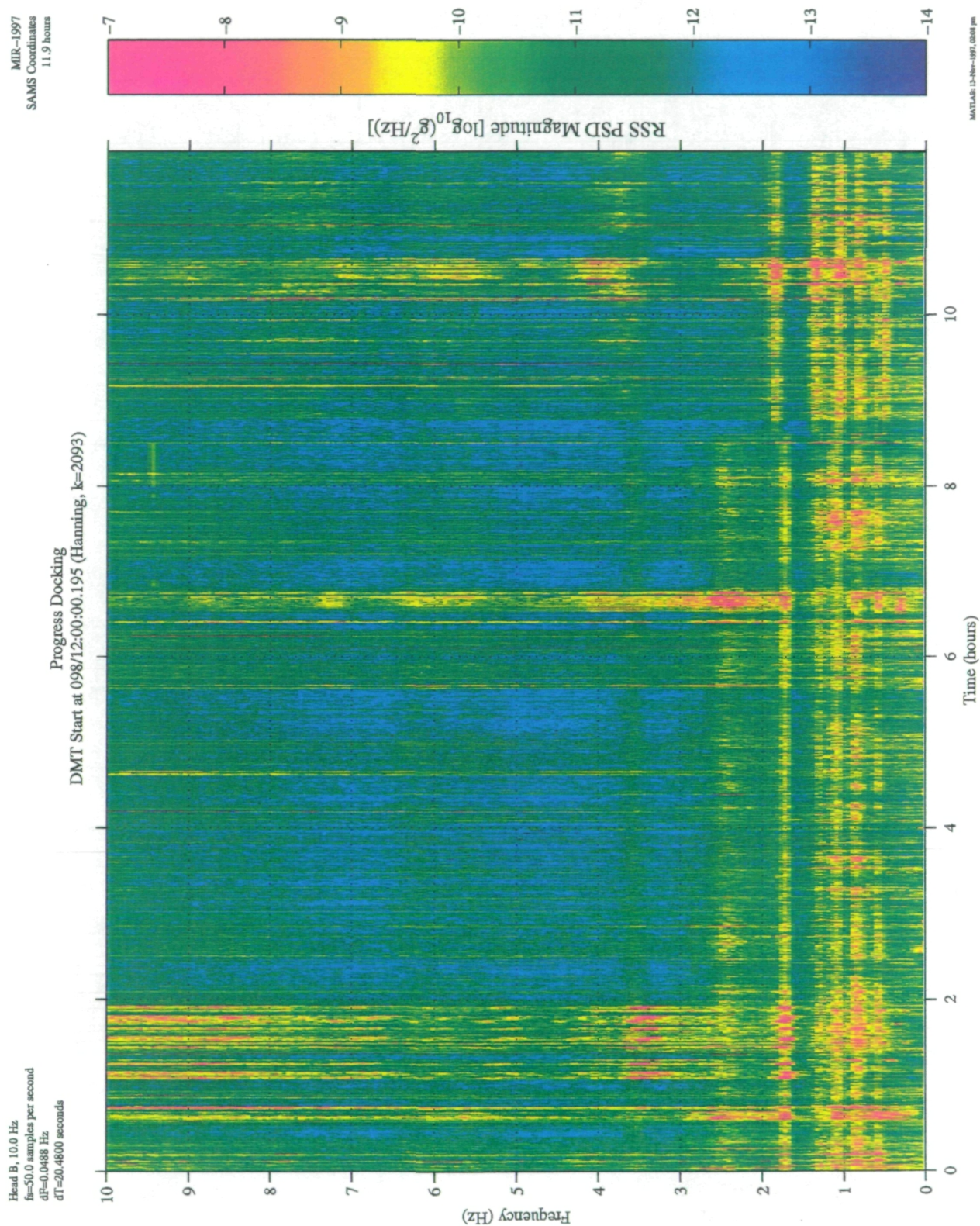
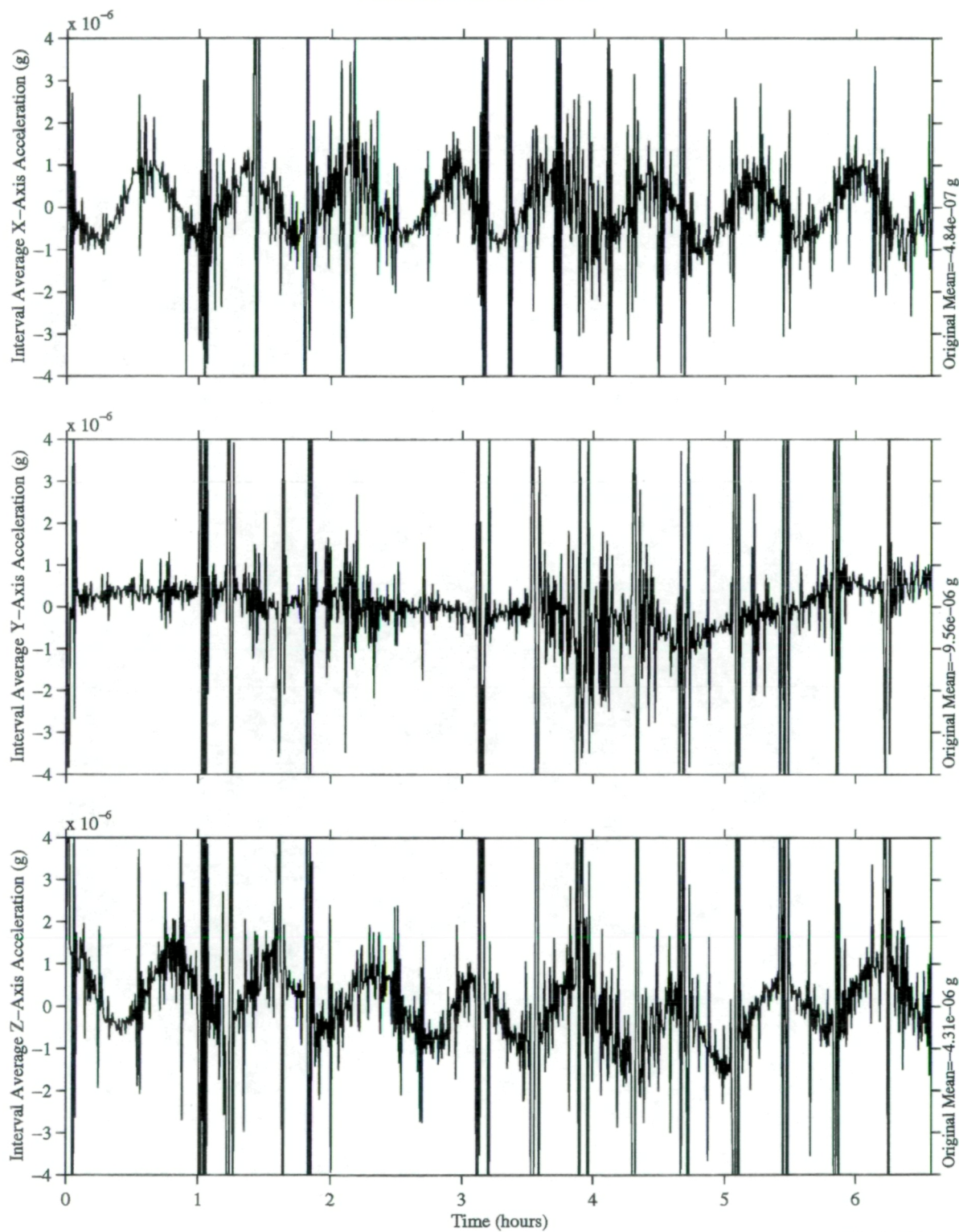


Figure 9. Progress docking

Head B, 10.0 Hz
fs=50.0 samples per second
Interval=30.00 seconds

Day 044
DMT Start at 044/10:00:00.115

MIR-1997
SAMS Coordinates
T=6.6 hours



MATLAB: 13-Nov-1997, 09:19 pm

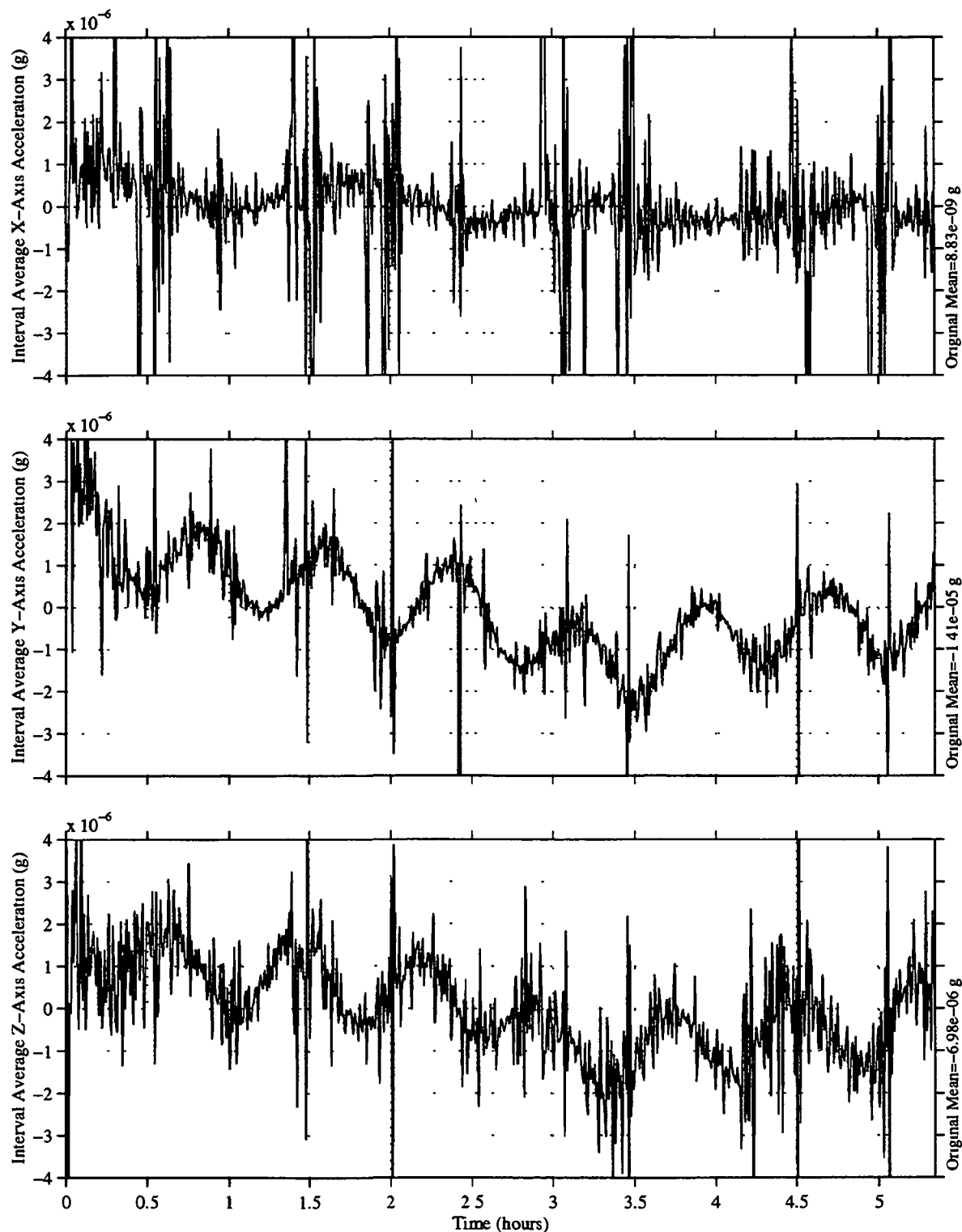
Figure 10. Earth-oriented attitude quasi-steady accelerations

SAMS ACCELERATION MEASUREMENTS ON MIR FROM JANUARY TO MAY 1997

Head B, 10.0 Hz
fs=50.0 samples per second
Interval=30.00 seconds

Day 054-055
DMT Start at 054/22:38 58.005

MIR-1997
SAMS Coordinates
T=5.4 hours



MATLAB, 15-Nov-1997 09:13 pm

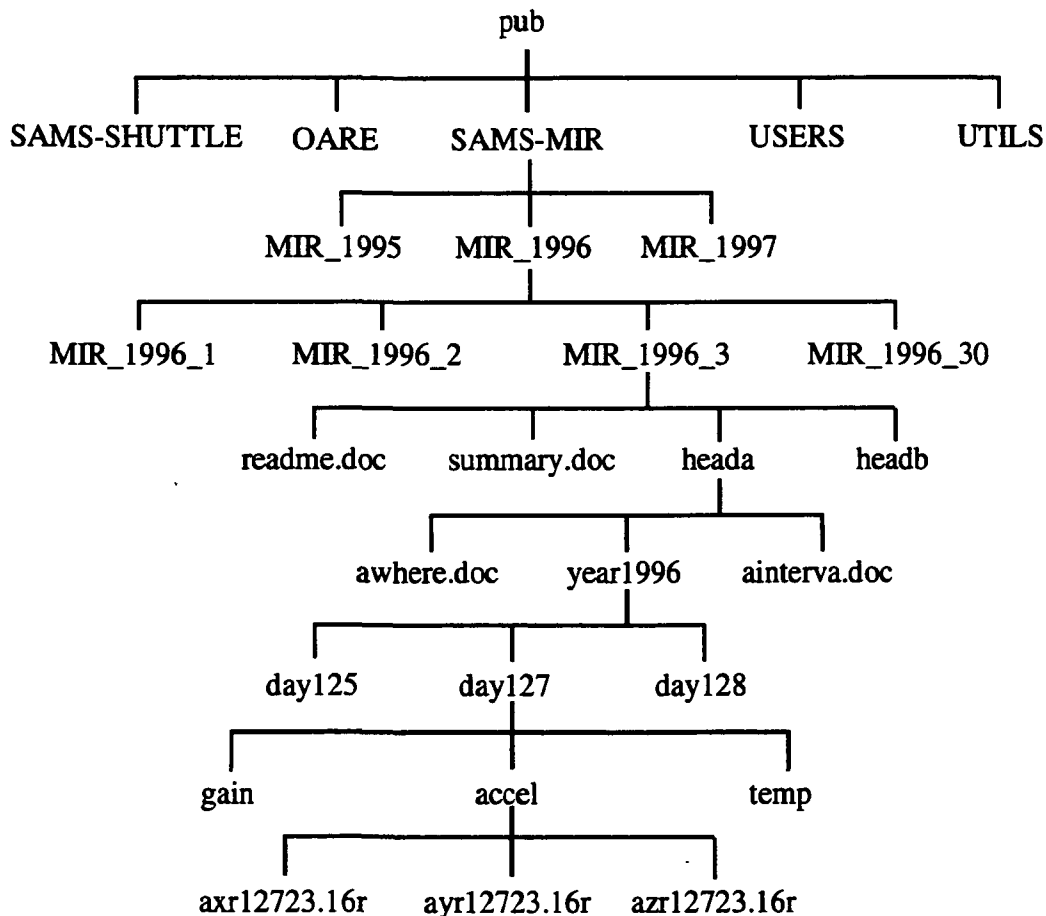
Figure 11. Solar inertial attitude quasi-steady accelerations

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Appendix A: Accessing Acceleration Data via the Internet

SAMS data are available over the internet from the NASA LeRC file server "beech.lerc.nasa.gov". Previously, SAMS data were made available on CD-ROM, but distribution of data from current (and future) missions will be primarily through this internet file server.

SAMS data files are arranged in a standard tree-like structure. Data are first separated based upon mission. Then, data are further subdivided based upon some portion of the mission, head, year (if applicable), day, and finally type of data file (acceleration, temperature, or gain). Effective November 1, 1996, there has been a minor reorganization of the beech.lerc.nasa.gov file server. There are now two locations for SAMS data: a directory called SAMS-SHUTTLE and a directory called SAMS-MIR. Under the SAMS-SHUTTLE directory, the data are segregated by mission. Under the SAMS-MIR directory, the data are segregated by year. The following figure illustrates this structure.



The SAMS data files (located at the bottom of the tree structure) are named based upon the contents of the file. For example, a file named "axm00102.15r" would contain head A data for the x-axis for day 001, hour 02, file 1 of 5. The readme.doc files give a complete explanation of the file naming convention.

Data access tools for different computer platforms (MS-DOS, Macintosh, SunOS, and MS-Windows) are available in the /pub/UTILS directory.

The NASA LeRC beech file server can be accessed via anonymous File Transfer Protocol (ftp), as follows:

- 1) Open an ftp connection to "beech.lerc.nasa.gov"
- 2) Login as userid "anonymous"
- 3) Enter your e-mail address as the password
- 4) Change directory to pub
- 5) List the files and directories in the pub directory
- 6) Change directories to the area of interest
- 7) Change directories to the mission of interest
- 8) Enable binary file transfers
- 9) Use the data file structures (described above) to locate the desired files
- 10) Transfer the desired files

If you encounter difficulty in accessing the data using the file server, please send an electronic mail message to "pims@lerc.nasa.gov". Please describe the nature of the difficulty and also give a description of the hardware and software you are using to access the file server. If you are interested in requesting specific data analysis or information from the PIMS team, also send e-mail to pims@lerc.nasa.gov or call the PIMS Project Manager, Duc Truong at (216) 433-8394.

Appendix B: SAMS Time Histories and Color Spectrograms TSH A

The Principal Investigator Microgravity Services (PIMS) group has further processed SAMS data to produce the plots shown here. This appendix presents power spectral density versus frequency versus time (spectrogram) plots of SAMS TSH A ($f_c=100$ Hz) data.

Color spectrograms are used to show how the microgravity environment varies in intensity with respect to time and frequency. These spectrograms are provided as an overview of the frequency characteristics of the SAMS data. Each spectrogram is a composite of 6 hour's worth of data. The time resolution used to compute the spectrograms seen here is 16.384 seconds. This corresponds to a frequency resolution of 0.0610 Hz.

These data were collected at 500 samples per second, and a 100 Hz lowpass filter was applied to the data by the SAMS unit prior to digitization. Prior to plot production, the raw SAMS data were compensated for gain changes, and then de-measured. De-meaning was accomplished by analyzing individual sections with a nominal length of 30 minutes. Since this de-meaning operation operates on time periods longer than the plot's time resolution, an artificial dc component may be seen in the extreme lower frequency regime of these spectrograms. Since these are data processing artifacts, the low frequency regime ($f < 0.05$ Hz) should be ignored. Users who are interested in further details for either of these operations are encouraged to contact the PIMS group.

Power Spectral Density versus Frequency versus Time Calculations

In order to produce the spectrogram image, Power Spectral Densities were computed for successive time intervals (the length of the interval is equal to the time resolution). For the PSD computation, a Hanning window was applied. In order to combine all three axes into a single plot to show an overall level, a Vector-Magnitude (VM) operation was performed. Stated mathematically:

$$VM_k = \sqrt{PSD_{x_k}^2 + PSD_{y_k}^2 + PSD_{z_k}^2}.$$

By imaging the base 10 logarithm (\log_{10}) magnitude as a color and stacking successive PSDs from left to right, variations of acceleration magnitude and frequency are shown as a function of time. Colors are assigned to discrete magnitude ranges, so that there are 64 colors assigned to the entire range of magnitudes shown.

The colorbar limits are chosen in order to maximize the data value and visibility in a given set of spectrogram plots. Data which fall outside of these limits will be imaged as either the highest or lowest magnitude, depending on which side they have saturated. For this report, less than 1% of the total points lie below the lower limit, and less than 1% of the total points lie above the upper limit. If an area of interest seems to be saturated, care should be taken in that the actual values may lie above or below the color mapping shown on the plot.

Due to the nature of spectrograms, care should be taken to not merely read a color's numeric value as being the acceleration magnitude that is present at a given frequency. In order to get this type of information, the PSDs must be integrated between two frequencies. These frequencies (lower and upper) form the band of interest. The result of this integration is the g_{RMS} acceleration level in the $[f_{\text{lower}}, f_{\text{upper}}]$ band. The PIMS group is able to provide this type of analysis on a per-request basis.

Plot gaps (if any exist) are shown by either white or dark blue areas on the page. Care should be taken to not mistake a plot gap (represented by a blue vertical band) with a quiet period. If a plot gap exists for an entire plot (or series of successive plots), a comment is placed on the page to let the user know there is a gap in the data. These "No data are available" comments will not show exact times for which the data are not available, but will only indicate missing plots.

Contacting PIMS

To request additional analysis or information, users are encouraged to send an e-mail to pims@lerc.nasa.gov, or FAX a request to (216) 433-8660.

Appendix C: SAMS Time Histories and Color Spectrograms TSH B

The Principal Investigator Microgravity Services (PIMS) group has further processed SAMS data to produce the plots shown here. This appendix presents power spectral density versus frequency versus time (spectrogram) plots of SAMS TSH A ($f_c=100$ Hz) data.

Color spectrograms are used to show how the microgravity environment varies in intensity with respect to time and frequency. These spectrograms are provided as an overview of the frequency characteristics of the SAMS data. Each spectrogram is a composite of 6 hour's worth of data. The time resolution used to compute the spectrograms seen here is 16.384 seconds. This corresponds to a frequency resolution of 0.0610 Hz.

These data were collected at 500 samples per second, and a 100 Hz lowpass filter was applied to the data by the SAMS unit prior to digitization. Prior to plot production, the raw SAMS data were compensated for gain changes, and then de-meanned. De-meaning was accomplished by analyzing individual sections with a nominal length of 30 minutes. Since this de-meaning operation operates on time periods longer than the plot's time resolution, an artificial dc component may be seen in the extreme lower frequency regime of these spectrograms. Since these are data processing artifacts, the low frequency regime ($f < 0.05$ Hz) should be ignored. Users who are interested in further details for either of these operations are encouraged to contact the PIMS group.

Power Spectral Density versus Frequency versus Time Calculations

In order to produce the spectrogram image, Power Spectral Densities were computed for successive time intervals (the length of the interval is equal to the time resolution). For the PSD computation, a Hanning window was applied. In order to combine all three axes into a single plot to show an overall level, a Vector-Magnitude (VM) operation was performed. Stated mathematically:

$$VM_k = \sqrt{PSD_{x_k}^2 + PSD_{y_k}^2 + PSD_{z_k}^2}.$$

By imaging the base 10 logarithm (\log_{10}) magnitude as a color and stacking successive PSDs from left to right, variations of acceleration magnitude and frequency are shown as a function of time. Colors are assigned to discrete magnitude ranges, so that there are 64 colors assigned to the entire range of magnitudes shown.

The colorbar limits are chosen in order to maximize the data value and visibility in a given set of spectrogram plots. Data which fall outside of these limits will be imaged as either the highest or lowest magnitude, depending on which side they have saturated. For this report, less than 1% of the total points lie below the lower limit, and less than 1% of the total points lie above the upper limit. If an area of interest seems to be saturated, care should be taken in that the actual values may lie above or below the color mapping shown on the plot.

Due to the nature of spectrograms, care should be taken to not merely read a color's numeric value as being the acceleration magnitude that is present at a given frequency. In order to get this type of information, the PSDs must be integrated between two frequencies. These frequencies (lower and upper) form the band of interest. The result of this integration is the g_{RMS} acceleration level in the $[f_{\text{lower}}, f_{\text{upper}}]$ band. The PIMS group is able to provide this type of analysis on a per-request basis.

Plot gaps (if any exist) are shown by either white or dark blue areas on the page. Care should be taken to not mistake a plot gap (represented by a blue vertical band) with a quiet period. If a plot gap exists for an entire plot (or series of successive plots), a comment is placed on the page to let the user know there is a gap in the data. These "No data are available" comments will not show exact times for which the data are not available, but will only indicate missing plots.

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To request additional analysis or information, users are encouraged to send an e-mail to pims@lerc.nasa.gov, or FAX a request to (216) 433-8660.

Appendix D: User Comment Sheet

We would like you to give us some feedback so that we may improve the Mission Summary Reports. Please answer the following questions and give us your comments.

1. Do the Mission Summary Reports fulfill your requirements for acceleration and mission information?
 _____ Yes _____ No. If not why not?

Comments:

2. Is there additional information which you feel should be included in the Mission Summary Reports?
 _____ Yes _____ No. If so what is it?

Comments:

3. Is there information in these reports which you feel is not necessary or useful?
 _____ Yes _____ No. If so, what is it?

Comments:

4. Do you have internet access via: (_____)ftp (_____)WWW (_____)gopher (_____)other?
 Have you already accessed SAMS data or information electronically?
 _____ Yes _____ No

Comments:

Completed by:

Name: _____	Telephone _____
Address: _____	Facsimile _____
_____	E-mail addr _____

Return this sheet to:
Duc Truong
NASA Lewis Research Center
21000 Brookpark Road MS 500-216
Cleveland, OH 44135

or
FAX to PIMS Project: 216-433-8660
e-mail to: pims@lerc.nasa.gov

REPORT DOCUMENTATION PAGE			Form Approved OMB No 0704-0188	
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE October 1998		3. REPORT TYPE AND DATES COVERED Technical Memorandum
4. TITLE AND SUBTITLE SAMS Acceleration Measurements on Mir From January to May 1997 (NASA Increment 4)			5. FUNDING NUMBERS WU-963-60-0D-00	
6. AUTHOR(S) Richard DeLombard				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135-3191			8. PERFORMING ORGANIZATION REPORT NUMBER E-11363	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546-0001			10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA TM-1998-208646	
11. SUPPLEMENTARY NOTES Responsible person, Richard DeLombard, organization code 6727, (216) 433-5285				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified - Unlimited Subject Categories: 18, 20, and 35 This publication is available from the NASA Center for AeroSpace Information, (301) 621-0390			12b. DISTRIBUTION CODE Distribution Nonstandard	
13. ABSTRACT (Maximum 200 words) During NASA Increment 4 (January to May 1997), about 5 gigabytes of acceleration data were collected by the Space Acceleration Measurements System (SAMS) onboard the Russian Space Station, Mir. The data were recorded on 28 optical disks which were returned to Earth on STS-84. During this increment, SAMS data were collected in the Priroda module to support the Mir Structural Dynamics Experiment (MISDE), the Binary Colloidal Alloy Tests (BCAT), Angular Liquid Bridge (ALB), Candle Flames in Microgravity (CFM), Diffusion Controlled Apparatus Module (DCAM), Enhanced Dynamic Load Sensors (EDLS), Forced Flow Flame Spreading Test (FFFT), Liquid Metal Diffusion (LMD), Protein Crystal Growth in Dewar (PCG/Dewar), Queen's University Experiments in Liquid Diffusion (QUELD), and Technical Evaluation of MIM (TEM). This report points out some of the salient features of the microgravity environment to which these experiments were exposed. Also documented are mission events of interest such as the docked phase of STS-84 operations, a Progress engine burn, Soyuz vehicle docking and undocking, and Progress vehicle docking. This report presents an overview of the SAMS acceleration measurements recorded by 10 Hz and 100 Hz sensor heads. The analyses included herein complement those presented in previous summary reports prepared by the Principal Investigator Microgravity Services (PIMS) group.				
14. SUBJECT TERMS Microgravity environment; SAMS, Shuttle; Mir; Acceleration measurements			15. NUMBER OF PAGES 39	
			16. PRICE CODE A03	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT	